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## NATURAL AND LABORATORY OCCURRENCE OF "ELYMI" PHENOTYPES IN *CYNTHIA CARDUI* (NYMPHALIDAE)

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THE "ELYMI" SERIES OF ABERRANT PHENOTYPES, characterized by suppression of the discal wing pattern, fusion of the dark subapical pattern elements, and development of a series of white submarginal spots, occurs in at least three species of the Holarctic genus *Cynthia*: *C. annabella* Field (= *C. carye* auct.), *C. virginensis* Drury, and *C. cardui* Linnaeus. The seasonal distribution and frequency of these phenotypes in wild populations of *C. annabella* in central California were recently reviewed by Shapiro (1973).

*Cynthia cardui* in California is a migratory species which rarely, if ever overwinters north of the Transverse Ranges. Transient populations occur in most of the state most years, generally shifting northward and upslope in mid-summer and sometimes showing a definite return flight southward in autumn. Although specimens representing various stages in the "elymi" series have been taken in many localities in California, no systematic search for them has been linked to seasonal movements and abundance of the species. The exceptionally large 1973 flight of *C. cardui* proved an opportunity for such an investigation.

In 1972, an "average" year, *C. cardui* was present in the Sacramento Valley from the third week of March to the first week in October, with the largest numbers flying in April, May, and the first half of June. No "elymi" phenotypes were reported anywhere in central California in 1972. In 1973 *C. cardui* first appeared the fourth week of February and reached "outbreak" proportions by mid-April. Very large populations persisted in the Valley until the third week of June, when most of the insects emigrated northward and upslope into the Sierra Nevada. During this period three generations appeared, feeding primarily on

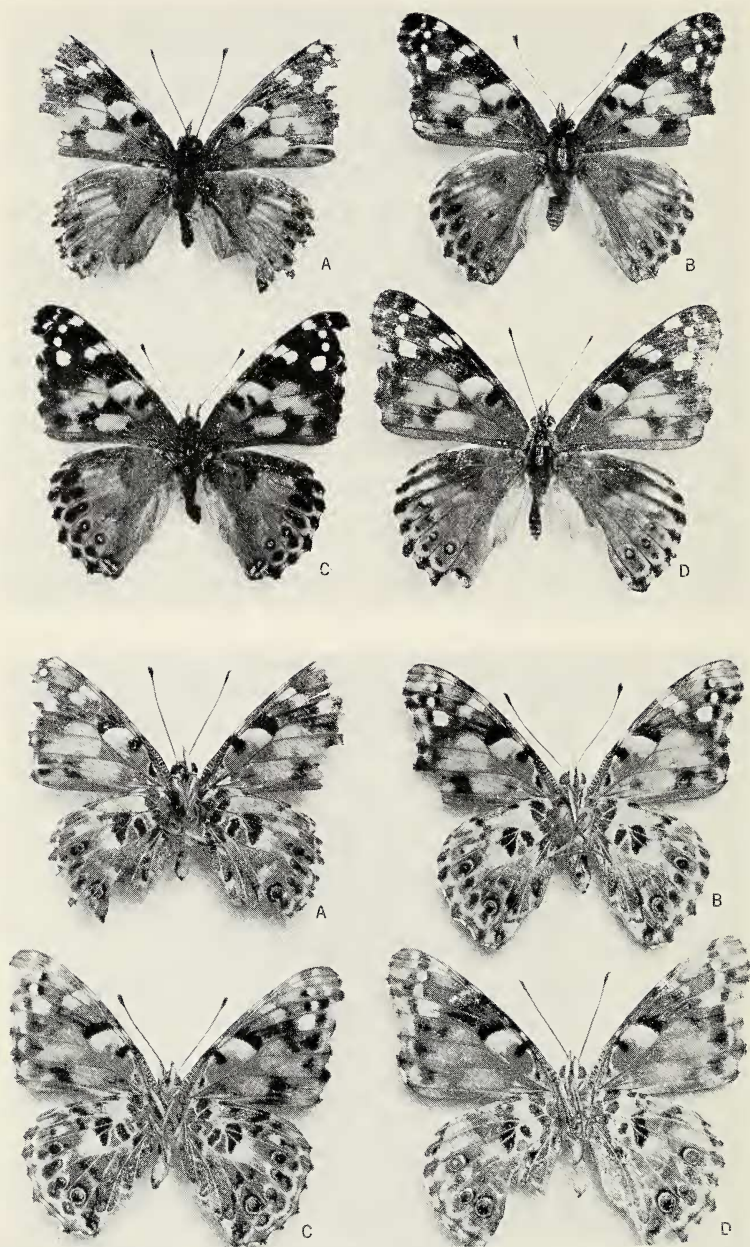


Fig. 1. — Aberrant *Cynthia cardui* collected in central California in 1973, upper and lower surfaces. For localities see text. A, v.25; B, vi.8; C, vi.2; D, ix.7.

*Silybum marianum* (L.) Gaertn. (Compositae), *Amsinckia* spp. (Boraginaceae), and *Malva*, spp. (Malvaceae). *C. cardui* remained in the Valley at low density through the hottest part of summer and occasional larvae could be found on *Centaurea solstitialis* L. (Compositae). From late August through September a significant southward movement through the Valley was observed. In the Sierra Nevada *C. cardui* was abundant in July and August and a major southward migration occurred in September at the same time as that in the Valley. Larvae were taken from *Cirsium* spp. and *Wyethia mollis* Grey (both Compositae). During the 1973 season five "elymi" phenotypes were reported in the Valley and two in the Sierra Nevada. An estimated 30,000 *C. cardui* were examined in the field during the season, giving a frequency of .00023, much below the .001 frequency observed for the corresponding phenotype of *C. annabella* (Shapiro, 1973).

Records of "elymi" specimens follow:

Sacramento Valley: American River, Sacramento (City) Co., California, v. 25:73 (♂), vi. 2.73 (♂ and second seen, sex undetermined); vi. 8.73 (♂). Broderick, Yolo Co., California, vi. 24.73 (seen, sex undetermined). (All A. M. Shapiro)

Sierra Nevada: East of Jerseydale, Mariposa Co., California, vi. 21.73 (♂) (O. Shields); Donner Pass, el. 7000': Placer Co., California, ix. 7.73 (♂) (A. M. Shapiro)

All of the captures except the Jerseydale specimen are shown in figure 1.

The most interesting aspect of this series is the cluster of records from the American River. All four specimens (the one missed on vi. 2 is definitely not the same individual taken vi. 8) were taken within an area one-half mile square and were in similar condition. Since *C. cardui* had been flying at the American River since March 2 they were probably locally bred, rather than immigrant individuals. Moreover, no aberrant specimens were seen at other Valley localities with equally dense *cardui* populations, despite comparable search. It is therefore likely that these four were siblings or at least that the "elymi" phenotype had a common (genetic or environmental) origin in all of them.

Dimock (1968) reported the induction of "elymi" phenotypes by holding fresh pupae of *C. cardui* at 36°F for 14 days. During the 1973 season numbers of large larvae of *C. cardui* were collected in the Valley and Sierra and the resulting pupae subjected to this treatment. Considerable variation occurred among the 37 adults obtained, but only seven were wild-type. In the remaining



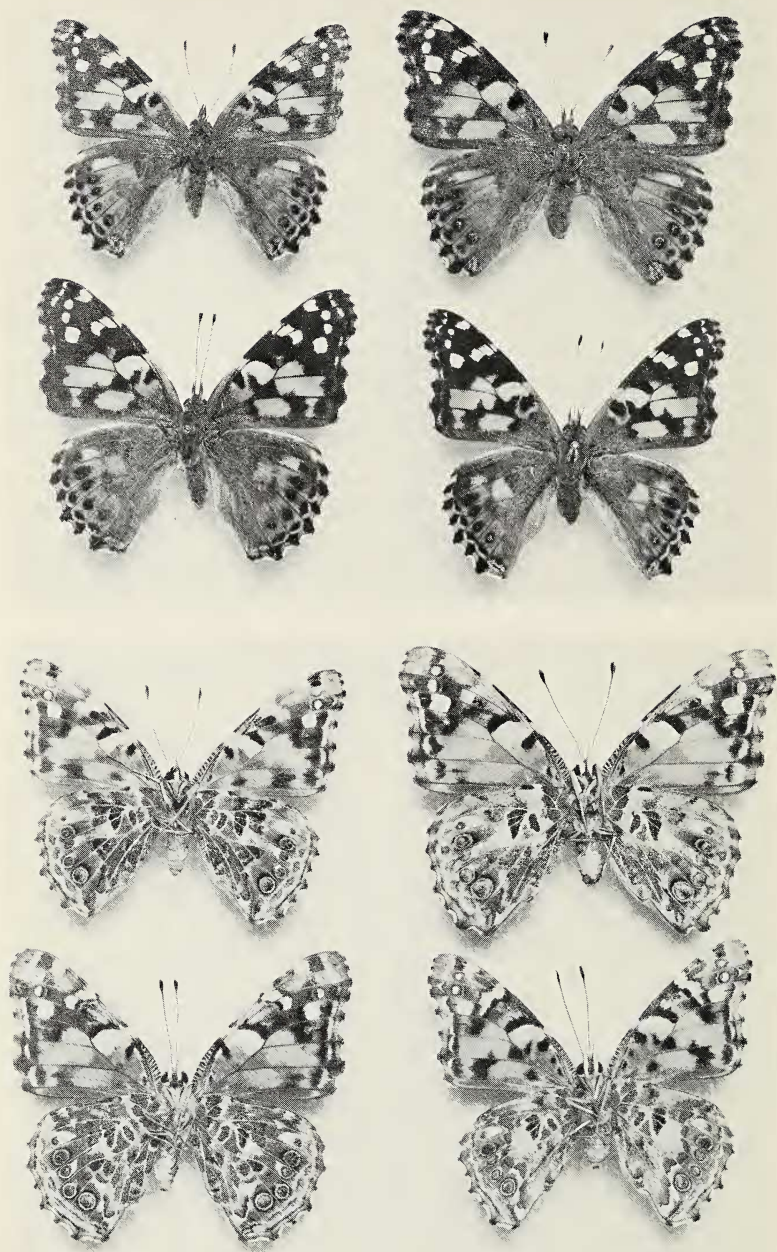


Fig. 2. — Aberrant *C. cardui* produced by chilling pupae at 36°F for 14 days. Upper and lower surfaces.



Fig. 3. — Normal *C. cardui* from pupae held at 90°F for 14 days. Upper and lower surfaces.

30 the pattern was more or less modified in the direction of "elymi" (occasionally on only the fore- or hindwings) (figure 2). Four specimens were indistinguishable from the wild "elymi" phenotypes. An additional 28 pupae died. Many of these developed fully but failed to eclose; all which had developed a pattern were "elymi," and a few were as extreme as Dimock's figure. In the control group of 30 unchilled pupae, 24 adults were obtained, all wild-type.

The dates and localities of the 1973 "elymi" (except the ix. 7 specimen) virtually exclude sustained (or severe but intermittent) chilling of the pupa as a causative agent. In an effort to determine if heating, a more likely factor afield, could induce "elymi" 21 pupae were subjected to 90°F until they hatched or for 14 days, whichever happened first. Three pupae so treated produced wild-type adults (Fig. 3) within 7 days; the remainder all died without depositing adult pigment.

"Elymi" phenotypes are produced with considerable regularity when fresh pupae of *C. cardui* are chilled, whether they come from low or high elevations. The individual batches tested are too small for any statements to be made as to the variance within local populations or among sibs with respect to this character, but it appears that the potential to produce "elymi" under temperature shock is inherent in normal *cardui*. The most promising hypothesis is that wild specimens of "elymi" are produced by genes or gene combinations which alter the threshold for expression of "elymi" so that it is produced under ordinary developmental conditions. This would make the experimental animals phenocopies, a familiar situation in genetics and one which predisposes to the evolution of phenotypic switch mechanisms through the mechanism called "genetic assimilation" (cf. Waddington, 1957). The occurrence of the phenotype in three species of *Cynthia* suggests that it may indeed have been a seasonal phenotype at one time in the evolution of the genus and that its expression was subsequently suppressed in a manner akin to the summer phenotype of *Pieris virginiensis* (Shapiro, 1971).

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